

# The Channel Tunnel Project

## Design of the TBM Backup System

In 1987 the Robbins-Markham Joint Venture (RMJV) was awarded a £15m contract to supply two machines for the Marine Rail tunnels driving some 22km towards France.

Bennett Associates was awarded a contract by RMJV to design and produce detail manufacturing drawings for the 235m long back-up system to the Tunnel Boring Machine (TBM) and a contract from the Robbins Company, USA to carry out a full Finite Element Stress Analysis of the Tunnel Boring Machine which they were designing.

### Design of the TBM back-up system

The back-up system consisting of thirteen articulated gantries, running on temporary rails, performs the following functions:

- Offloads, transports and places 1.5m wide precast concrete segments in position to form to form the tunnelling lining. The 45 ton segment ring in nine pieces has to be built in 15 minutes.
- Transport muck from the cutterhead on conveyors at a peak rate of 1,500 and normal rate of 1000 tonnes per hour.
- Supports the TBM with all services paid out continuously as the machine advances. The power supply is 2,300kw at 11,000 volt, clean water in by 4" dia hose reel, dirty water out by 6" dia hose reel, inrush water out 12" dia x 2 telescopic pipes, fresh air in by 2m dia flexible duct plus radio telephone and computer data links.
- Performs and supports a high pressure grouting system, filling voids between pre-cast lining and the ground.
- Provides air extraction and cleans by filtration and wet scrubbing prior to discharge.
- Provides compressed air, fire fighting systems, emergency power and workshop/messroom facility.
- Houses the TBM and back-up system air conditioned sound proof control room and hydraulic powerpacks and electrical control gear.

Some 800 drawings were produced, mainly using AutoCad, over a ten month period. Qualified engineers were on site during the tunnelling period, assisting with machine operation and modification to suit changing ground conditions.

### Stress analysis of TBM

The 12m long TBM weighing some 800 tonnes was designed to withstand the full hydrostatic head of sea pressure of 12 bar, exerting a force of 6,600 tonnes on the front of the TBM.

The machine is propelled forwards by hydraulic rams able to provide 4220 tonnes of thrust reacted by gripper pads thrust out against the tunnel bore.

Bennett Associates was responsible for carrying out a full stress analysis of the cutterhead support, TBM structure and gripper body and pads which was done by Finite Element analysis using ANSYS software solid modelling elements.

The analysis was used interactively by the Robbins designers in Seattle USA. Close co-operation was maintained by visits to Seattle and exchange of AutoCAD drawings on disk to ensure that the complex interface between TBM and its back-up system was correctly engineered.

Bennett Associates (originally founded in 1984) was acquired in 2008 by Atkins; bringing their proven technical expertise to the UK's leading engineering consultancy.

### Atkins Ltd

Bennett House, Pleasley Road, Whiston, Rotherham, S60 4HQ, UK. Tel: +44 (0)1709 373782  
[www.bennettmg.co.uk](http://www.bennettmg.co.uk)

